# Data Sciences

## Lawrence Livermore National Laboratory

Do you need sophisticated tools for data-based decision analysis? Lawrence Livermore can turn highly complex, multi-modal data sets into information that can be applied to actionable decisions, optimally deployed resources, and informed tradeoffs. With our state-of-the-art data analysis techniques and deep experience, we can provide the best solutions to difficult decision-making problems.

### Success Stories

**Cyber Security**
- Behavioral modeling through machine learning

**Global Security**
- Real-time data processing and content inference of large-scale video surveillance
- Systems modeling and analysis for global nuclear detection architecture
- Mixed integer optimization modeling to guide radiological and nuclear search missions
- Incorporating uncertainty in intelligence data to models of adaptive adversary behavior
- Bayesian inference methodology for detecting WMD terrorism activities using ambiguous indicators

**Nuclear Weapons/Nuclear Enterprise**
- Uncertainty quantification applied to weapons engineering
- Optimization models to inform enterprise decisions
- Mixed integer optimization models for sustainment decisions for the nuclear enterprise

**Energy and Climate Science**
- Statistical inversion to locate micro-seismic hydraulic fracturing activity
- Uncertainty quantification for renewable energy forecasting and climate modeling
- Large-scale discrete optimization for electric grid operations planning
- Clustering methods for weather data in generation of stochastic optimization scenarios

**Biosciences**
- Data mining for bioinformatics
- Disease models and simulations for evaluating epidemic countermeasures



Spurious tracks
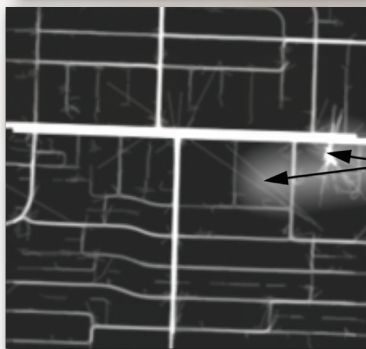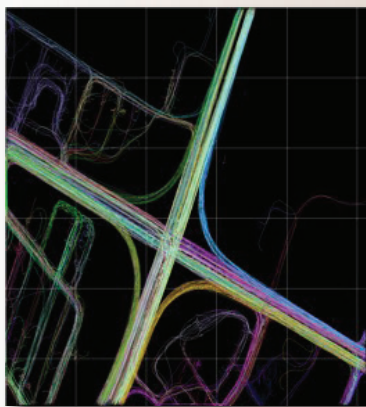
**Cluster analysis of vehicle traffic (top) is used to build models of normal behavior. Deviations from these models can be used to cue analysts to anomalous activity.**
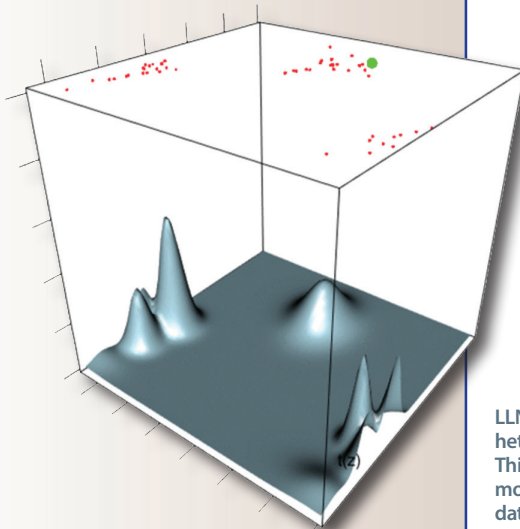


LLNL's composite mixture modeling enables probability density estimation over heterogeneous feature types in both streaming and batch retrospective settings. This figure shows the probability density learned by a streaming composite mixture model with multiple Gaussian and Von Mises (circular Gaussian) components fitting data points as they stream in.

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## Unique Infrastructure

- State-of-the-art techniques in machine learning, statistics, and decision sciences
- Tools required to turn large, highly complex and multi-modal data sets into actionable information
- Expertise to customize solutions to unique data analysis problems
- Custom models for analyzing complex systems and informing decisions

## Sponsors

- Department of Energy
- Department of Defense
- California Energy Commission/ California Public Utilities Commission
- Kaiser Permanente

## Academic Alliances

- University of California Berkeley
- Stanford University
- University of California Davis
- University of California Santa Cruz

## Staff

Data science experts specialize in decision sciences, statistics, and machine learning.
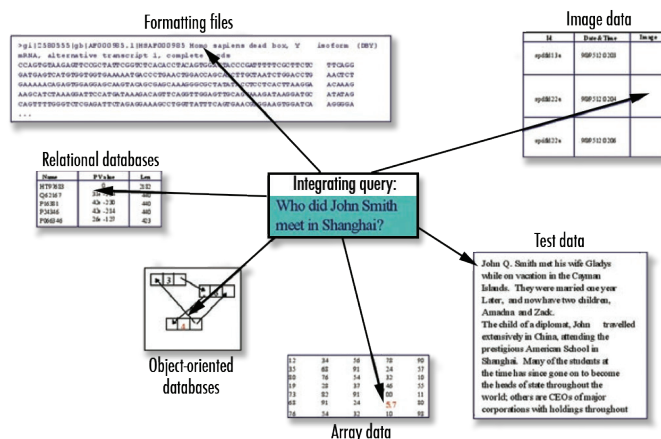


The diversity of data possibly needed to answer a query includes formatted and raw text files, image data, and various other databases.
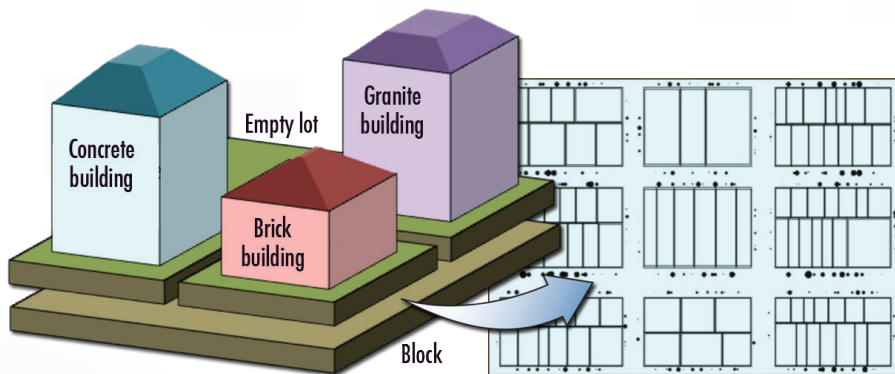


LLNL has developed models and simulations to guide radiological and nuclear search missions in urban settings. The goal is to increase the effectiveness and efficiency of search missions and provide a confidence estimate of the result by exploiting information in realistic environments. An Urban Scene Simulator defines the physical properties of the environment and estimates background radiation and attenuation due to buildings. An optimization model computes the optimal search strategy in order to detect a source or "clear" the region in minimum time at a given confidence level. Simulated results have shown that optimized searches can be 3 to 30 times faster than constant speed searches.

## Capability Leader

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Jim is the Deputy Division Leader with Engineering's Computational Engineering Division and Section Leader for the Data Analytics and Decision Sciences Section. His areas of technical expertise include systems modeling and analysis, simulation, decision analysis and operations research. His B.S. in industrial engineering is from the University of Illinois. He also holds a M.S. in operations research from the University of California, Berkeley.